REMOPLEURIDES AND OTHER UPPER ORDOVICIAN TRILOBITES FROM NEW SOUTH WALES

by B. D. WEBBY

ABSTRACT. Thirteen trilobite species are described and illustrated from Upper Ordovician successions of central New South Wales. They include the new species, *Remopleurides saenuros*, *R. exallos*, *R. acer*, *Pseudobasilicus*? *fortis*, and *Illaenus* (*Parillaenus*)? *incertus*, and records of *Shumardia*, *Geragnostus*?, and a harpid. A discussion of possible dimorphism in *Remopleurides* is presented.

IN previous contributions on the Upper Ordovician trilobite fauna of central New South Wales, several new genera and species were proposed. Webby, Moors, and McLean (1970) introduced the new genera *Malongullia* and *Encrinuraspis*, and Campbell and Durham (1970), *Parkesolithus*. In the following year Webby (1971) added two new species of *Pliomerina*. The present work completes descriptions of the Upper Ordovician agnostids, shumardiids, remopleuridids, asaphids, illaenids, and harpids from central New South Wales based on collections housed in the Department of Geology and Geophysics, University of Sydney.

The faunas have been collected through a considerable stratigraphic thickness of beds, and from widely scattered localities on the Molong Rise and Parkes Platform of the Lachlan Geosyncline (Packham 1969). *Remopleurides acer* sp. nov. and *Pseudobasilicus*? *fortis* sp. nov. occur with *Pliomerina prima* Webby and a scutelluid (not *Eobronteus*) in the lower part of the Cliefden Caves Limestone. *R. saenuros* sp. nov., *R.* sp. A, *Pseudobasilicus*? sp. A, and a harpid are represented, together with *Pliomerina austrina* Webby, *Amphilichas*, *Sphaerocoryphe*, and an encrinurid, in the Ordovician limestone at Billabong Creek, considered to be approximately equivalent in age to the upper part of the Cliefden Caves Limestone. Another, stratigraphically younger fauna, with *Illaenus* (*Parillaenus*)? *incertus* sp. nov. as the dominant form, is found in calcarenites at the top of the Ballingoole Formation (upper part of the Bowan Park Group of Semeniuk 1970). Other elements of the fauna are too fragmentary to determine to species level, but include *Remopleurides*, an asaphid, a proetid, a trinucleid, and encrinurid. The three stratigraphically distinct trilobite faunas from the limestones correlate quite well with the three stromatoporoid/coral faunas I, II, and III outlined previously (Webby 1969).

In the shales of the Malongulli Formation, directly overlying the Cliefden Caves Limestone, at Trilobite Hill and Copper Mine Creek, *R. exallos* sp. nov., *Malongullia oepiki* Webby, Moors, and McLean, *Encrinuraspis optimus* Webby, Moors, and McLean, *Parkesolithus*, and a scutelluid (not *Eobronteus*) are found. These beds, from their associated graptolites (Moors 1970), are taken to have an Upper Eastonian age (*Dicranograptus hians* Zone). A similar fauna has been collected from near Mirrabooka homestead, north of Cheeseman's Creek, with additions of *R.* sp. B, *Illaenus* (*Parillaenus*)? sp. A, and *Toernquistia*. Another distinct species of *Remopleurides*, *R.* sp. C, occurs in a near-by locality, just north of the Cheeseman's Creek

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Post Office, and possibly comes from a higher stratigraphic horizon. The scutelluids from the lower part of the Cliefden Caves Limestone and the Malongulli Formation, previously assigned to *Eobronteus* (Webby 1971, p. 612; Whittington and Hughes 1972, p. 273), more correctly belong to a new genus having closest affinities to the Silurian genera *Kosovopeltis* Šnadjr and *Planiscutellum* R. and E. Richter.

The beds of the Oakdale Formation in the Mumbil area, with their *Geragnostus*? and *Shumardia*, have previously been assigned an Upper Eastonian age on the basis of occurrences of associated species of *Climacograptus*, *Dicellograptus*, and *Orthograptus* (Strusz 1960, 1961). They could be comparable in age to the beds of the Malongulli Formation, but are probably slightly older, perhaps Gisbornian or Lower Eastonian (above the base of the *Nemagraptus gracilis* Zone). It seems that the Oakdale Formation includes two separate successions, an older belt to the west containing the 'upper Eastonian' graptolites, and *Geragnostus*? and *Shumardia*, and a much younger sequence in the core of the Oakdale anticline to the east, with a rich coral fauna at the top, suggesting either an Upper Bolindian or, more probably, a late Llandoverian age (see further discussion in Webby 1972).

Pittman (1900, p. 10) has recorded a probable agnostid from Ordovician graptolitic shales at Junction Reefs, near Mandurama. Alluding to this same trilobite, Chapman (1914, p. 227) related it to *Shumardia*. Stevens (1957, p. 48) considered the beds containing the trilobite to be associated with occurrences of *Glyptograptus teretiusculus*, and Smith (1966) grouped these beds in the Malongulli Formation. The region is east of the type area of the Malongulli Formation (Upper Eastonian age) near Cliefden Caves, and the beds contain definite Darriwilian (Llanvirn–Llandeilo) graptolite assemblages (Packham 1969, p. 80). According to Packham, the upper limit of age of these beds is probably near the base of the Eastonian. Smith's 'Malongulli Formation' is therefore a distinct, older, Darriwilian–Gisbornian unit. Pittman's original trilobite is confirmed as a species of *Shumardia* closely similar to the Oakdale form. It is possible that it is conspecific with the Oakdale species. Perhaps both come from similar, Gisbornian, horizons.

In the silicified residues from the Ordovician limestone at Billabong Creek (Packham 1967), there is abundant material belonging to the small species of *Remopleurides*, *R. saenuros*, allowing virtually complete description, and fragmentary specimens of the thorax and pygidium of a much larger and broader form, *Remopleurides* sp. A (Pl. 52). The cephalon and anterior thoracic segments of this latter form remain unknown, but it can be estimated to have been about four times larger than *R. saenuros*. It is relatively much broader, especially across the axis, and appears to lack a median axial spine on the third thoracic segment in front of the pygidium. It has a large, rather undifferentiated, sub-trapezoidal, posteriorly rounded pygidium, totally different from the pygidium of *R. saenuros*, which has a weakly differentiated triangular axis, two pairs of short pleural spines, and a deeply incised median longitudinal furrow. Another very large, incomplete and rather similar specimen, referred to *Remopleurides* sp. B, occurs in the shales of the Malongulli Formation associated with *R. exallos* (Pl. 51, figs. 3–13). These associations suggest the possibility of the New South Wales *Remopleurides* exhibiting a most distinctive type of dimorphism, though the cephalon of the large form must be found to demonstrate the relationship convincingly. Whittington (1963) has mentioned the possibility of dimorphism be-

tween his two species of *Remopleurides*, *R. eximius* and *R. simulus*, from the Lower Edinburg Formation of eastern North America, but these are separated by comparatively minor morphological characteristics compared with the features distinguishing the large and small New South Wales forms. *R. eximius* has a tiny spine at the genal angle, long, curving pleural spines on the seventh thoracic segment, and deep furrows on the pygidial axis. *R. simulus*, in contrast, has a slender spine originating in front of the genal angle, the pointed ends of the pleurae are equally extended, the axis of the pygidium is less inflated, the furrows shallower, and it is only about two-thirds the size of *R. eximius*.

A micrometer ocular and, for larger dimensions, a pair of dividers have been used for taking measurements. Unfortunately, however, there are considerable errors in taking linear measurements across curved surfaces of exoskeletons, especially in more highly convex forms. Therefore, only measurements taken across less convex surfaces are cited.

SYSTEMATIC DESCRIPTIONS

Family AGNOSTIDAE McCoy 1849
Genus GERAGNOSTUS Howell 1935

Type species. Agnostus sidenbladhi Linnarsson 1869

Geragnostus? sp.

Plate 51, fig. 1

Material. One internal mould of a fairly complete specimen (SUP 26900) from locality G (Strusz 1961, p. 334, text-fig. 1) of the Oakdale Formation, 1½ miles NNE. of Newrea, south of Wellington.

Description. Although margins of cephalon not exposed, general appearance suggests subquadrate outline; slightly wider than long. Glabella expanded anteriorly, bounded by deep, broad axial and preglabellar furrows, and divided into anterior and posterior lobes by pronounced transglabellar furrow situated about glabellar mid-length, slightly convex forwards. From nature of freshly broken surface immediately behind transglabellar furrow, it seems likely that small median glabellar node may have been present originally. Anterior lobe gently convex, widest just behind mid-length (sag.), wider than long, with convexo-concave outline. Posterior lobe narrower (tr.), moderately strongly convex, parallel-sided with posterior part sloping steeply backward and having sharply V-shaped posterior outline. V-shaped occipital furrow separates posterior lobe from pair of triangular, lateral occipital lobes (Whittington 1963, p. 28).

Cheeks and preglabellar area convex, with narrow, steeply sloping inward edge to axial and preglabellar furrows, and wider more gently sloping outward margin. Border unknown.

Thorax of two segments, subequal in size. Axis of anterior segment broad, divided into median trapezoidal lobe and pair of ovate lateral lobes elongated inward and forward at about 45°; each pleura divided almost equally by pleural furrow. Posterior segment similar, differing in having more obviously quadrate median lobe, suboval lateral lobes elongated transversely, and each pleura curving forward with prominent pleural furrow situated on anterior part.

Pygidium slightly wider than long; axis convex, rounded posteriorly, and widest about mid-length, limited by deep, broad axial furrows. Transverse furrow well defined, gently concave anteriorly and situated about one-third of total length of axis from anterior margin. Anterolateral corners of axis exhibit pair of elongated, triangular-shaped lobes. Weakly developed rounded median node forms highest point on pygidium, just in front of transverse furrow. Posterior lobe of axis has concavo-convex outline. Inner edge of pleural lobes inclined steeply in towards axial furrow; outwardly more or less of equal width and convexity, bounded by border furrow. Border poorly preserved; no spines seen. Ornamentation not observed.

Remarks. The New South Wales species seems to be nearest to *Geragnostus mccoyii* (Salter) from the Llandeilo and basal Caradoc of Wales and the Welsh Borderland (Whittard 1955; Hughes 1969), a form with a deeply impressed transglabellar furrow. However, it has a much more expanded anterior glabellar lobe, more sharply V-shaped posterior margin to the posterior lobe of the glabella, and more or less equal thoracic segments. Since the borders are incompletely preserved and the anterior glabellar lobe is rather enlarged, the species is only tentatively assigned to the genus.

Species of *Geragnostus*, as Whittington (1963, 1966) has pointed out, range from Upper Cambrian to Middle Ordovician, with a doubtful record in the Ashgill of Poland (Kielan 1960), and have a wide geographical distribution. There seems to be no known occurrence of a species of *Geragnostus* with strongly developed transglabellar furrow in beds younger than basal Caradoc.

EXPLANATION OF PLATE 51

Fig. 1. *Geragnostus*? sp. Dorsal view of internal mould of incomplete exoskeleton from Oakdale Formation near Newrea; SUP 26900, ×6.

Fig. 2. *Shumardia* sp. Latex impression of cephalon from Oakdale Formation, near Newrea; SUP 26901, ×8.

Figs. 3–12. *Remopleurides exallos* sp. nov., from the Malongulli Formation. 3–4, 6, 9–10, and 12 from Copper Mine Creek, 11 from Trilobite Hill, and 5, 7–8 from near Mirrabooka homestead, Cheeseman's Creek area. 3, Dorsal view of latex impression of external mould of cranidium; holotype SUP 28913, ×4. 4, Dorsal view of internal mould of cranidium; paratype SUP 19937, ×5. 5, Oblique view of latex cast of external mould of cranidium; paratype SUP 27905b, ×6. 6, Partly disarticulated specimen showing internal mould of dorsal side of part of cranidium and two thoracic segments, and ventral side of last three thoracic segments and pygidium; paratype SUP 28911a, ×6. 7–8, Oblique views of internal and external moulds of left free cheek; paratype SUP 28905, ×6. 9, Ventral view of compressed specimen showing internal mould of anterior part of doublure and large pit, and external mould of free cheek with distinctive anastomosing lines; paratype SUP 28914, ×6. 10, Dorsal view of latex impression of external mould of two thoracic segments; paratype SUP 26942b, ×4. 11, Ventral side of thoracic pleurae; paratype SUP 19917, ×8. 12, Dorsal view of latex cast of external mould of articulated posterior part of exoskeleton with four thoracic segments and pygidium. Note median axial spine on third thoracic segment in front of pygidium; paratype SUP 28910, ×6.

Fig. 13. *Remopleurides* sp. B from the Malongulli Formation near Mirrabooka homestead, Cheeseman's Creek area; SUP 28904, ×2. Internal mould of six thoracic segments and damaged pygidium.

Figs. 14–15. *Remopleurides* sp. C. Ventral and dorsal views of latex impressions of left free cheek from shales just north of Cheeseman's Creek P.O.; SUP 28908, ×4.


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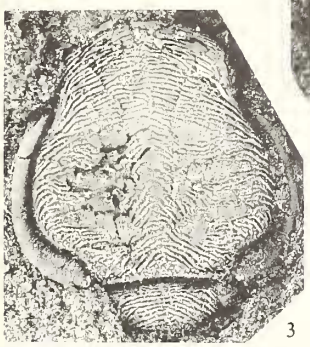
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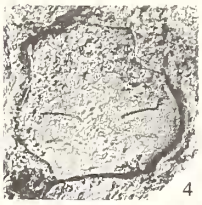
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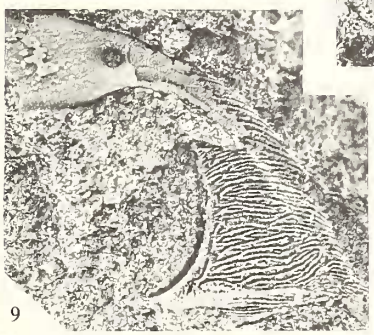
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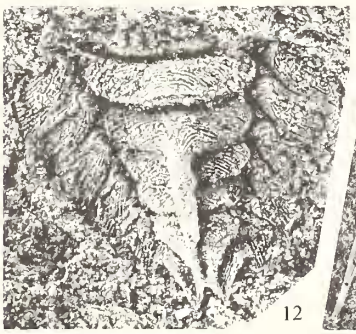
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WEBBY, *Geragnostus*?, *Shumardia*, *Remopleurides*

Family SHUMARDIIDAE Lake 1907
Genus SHUMARDIA Billings 1862

Type species. S. granulosa Billings 1862

Shumardia sp.

Plate 51, fig. 2

Material. An incomplete external and internal mould of a cephalon (SUP 26901) and a fragment of the thorax (SUP 26902) from locality G (Strusz 1961, p. 334, text-fig. 1) of the Oakdale Formation, 1½ miles NNE. of Newrea, south of Wellington.

Description. Cephalon convex, approximately subsemicircular; glabella occupying almost one-half cephalic width. Anterior part of glabella expanded with pair of elongate, ovoid antero-lateral lobes, isolated by lateral glabellar furrow *2p* running forward and slightly inward from deeply indented axial furrow; posterior part of glabella semicylindrical; lateral glabellar furrow *1p* not seen, and apparently no basal lobes. Antero-lateral lobes narrower than intervening frontomedian lobe of glabella. Axial furrow deeply impressed in posterior part of glabella but shallows as it curves forward around antero-lateral lobe, being confluent with preglabellar furrow, and coming together with a V-shaped outline, viewed from the front, with an angle of about 90° between either side. Occipital furrow separates convex occipital ring from rest of glabella; slightly wider than posterior part of glabella.

Cheek convex, sloping steeply distally, especially postero-laterally, narrowing into preglabellar area anteriorly; also sloping steeply into posterior part of axial furrow. Facial suture not observed. Posterior border furrow not shown. Surface of cephalon appears to be unornamented.

Remarks. A specimen (MMF. 3414) in collections of the Geological and Mining Museum, Geological Survey of N.S.W., from Ordovician graptolitic shales near Junction Reefs, Mandurama (Pittman 1900), proves to exhibit a species of *Shumardia* which may be conspecific with the Oakdale form. The slab shows two separate cephala and a pygidium. The form and size of the cephala are similar to that of the Oakdale species. The relatively slightly shorter, less slender glabella is probably not a significantly diagnostic feature for differentiation of a separate species. These specimens exhibit a little more of the posterior part of the cheek than in the Oakdale cephalon. The posterior border is very deep, and undercuts the cheek on its inner course, but shallows and curves slightly forward distally, dying out inside the lateral margin, and not apparently continuous into a lateral border furrow. The posterior border has a prominent wedge-shaped, distally widening outline. The pygidium is subtriangular, with raised, almost smooth axis, tapering backward to bluntly rounded point. Anteriorly, the articulating furrow and articulating half-ring are well developed. Seven very weakly differentiated axial rings are seen. The pleural regions exhibit a prominent first pair of pleural furrows, curving backward and outward to the posterior edge of the articulating facet, and the next three, progressively shorter and much weaker. Posteriorly the pleural regions are smooth. Broad (sag.), shallowly curved posterior border furrow separates an elongated, flattened, tongue-like posterior border from the steeply declined, convex pleural region behind the axis.

An internal mould of the pygidium shows the inner edge of the doublure extending from immediately behind axis in smooth, gentle curve antero-laterally toward posterior edge of articulating facet, with the result that the doublure has a much expanded, crescent-shaped outline. Pygidia of Koroleva's (1964) species of *Shumardia*, *S. lacrima* and *S. analoga*, from the Middle Ordovician of northern Kazakhstan, seem to show a similar tongue-like projection of the posterior border, but both exhibit more conspicuous differentiation of axial rings and pleural ribs.

The Oakdale species appears to bear close resemblances to *S. minutula* Harrington from the Upper Tremadoc and Arenig of Argentina (Harrington and Leanza 1957). However, the glabella differs in being better differentiated with longer and more slender antero-lateral lobes. *S. sagittula* Whittington (1965) from the Middle Table Head Formation of Newfoundland may also be compared, but has a longer (sag. and exsag.) occipital ring, a shorter subcylindrical part of glabella in front of occipital furrow and more bulbous antero-lateral lobes. The present species bears little resemblance to known Upper Ordovician species, *S. scotica* Reed (1903) from the Whitehouse Group (late Caradoc or early Ashgill) of Girvan, Scotland, and *S. polonica* Kielan (1960) from the Middle Ashgill of Poland. The posterior part of the glabella of both these species is much broader, and they exhibit weakly differentiated basal lobes and a relatively wider occipital ring. Of Koroleva's (1964) species of *Shumardia* from the Middle Ordovician of northern Kazakhstan, *S. analoga* has most similar cephalic proportions, but differs in exhibiting slightly shorter (exsag.) antero-lateral lobes, and sub-quadrate outline of both anterior parts of the cephalon and the glabella. The outline of both the cephalon and glabella of the Oakdale species is more conspicuously V-shaped anteriorly.

Family REMOPLEURIDIDAE Hawle and Corda 1847
Genus REMOPLEURIDES Portlock 1843

Type species. R. colbii Portlock 1843; subsequently designated by Miller 1889.

Remopleurides saenuros sp. nov.

Plate 52, figs. 1–28

Material. Holotype (SUP 27932) and eleven paratypes (SUP 27933–27936, 27938–27941, 27948–27949, 28900) from Ordovician limestone at Billabong Creek. All fragmentary silicified specimens.

Description. Glabella convex, especially anteriorly along sagittal line, less convex transversely; glabellar tongue broad, elevated, vertical to very slightly overhanging anterior cephalic margin. Maximum width of glabella about three-fifths total distance behind anterior margin (sag.). Length of glabella (including occipital ring) slightly greater than maximum width. Width at base of glabellar tongue slightly more than width at base of median glabellar area, adjacent to occipital furrow; glabellar tongue exhibits slight widening towards antero-lateral extremities. No lateral glabellar furrows visible. Occipital ring gently convex, set below raised median glabellar area, elongate (sag. and exsag.) but tapering rapidly towards distal ends; occipital furrow transverse, with steep slope in front on to median glabellar area.

Glabellar tongue bounded laterally by axial furrow, with small anterior pit placed in furrow at antero-lateral extremity; preglabellar furrow continuous with axial furrow, becoming shallower and closer to anterior margin until it dies out a short distance in from extremities. As seen in frontal view, anterior margin flattened to very weakly concave ventrally (Pl. 52, fig. 3). Axial furrow continuous with palpebral furrow to rear. Palpebral rim flat, tilted slightly forward and outward (eye lobe has similar tilt), widens posteriorly to maximum width adjacent to postero-lateral part of median glabellar area; narrows rapidly as it descends to occipital furrow. Posterior area of fixed cheek narrow (exsag.), relatively short (tr.), though not for genus, near horizontal, tapering towards backwardly deflected tip; articulation with first thoracic segment facilitated by small axial process on axial furrow, gently transversely arched posterior flange and large fulcral sockets at distal end of posterior area (Pl. 52, figs. 1, 6–7). Doublure extends forwards slightly more than one-half sagittal length of occipital ring. Surface ornamentation on glabella and occipital ring consists of faint Bertillon pattern of lines; also row of small granules developed along posterior margin of occipital ring (Pl. 52, fig. 7).

Eye lobe long (exsag.) with visual surface curved through about 150°; anterior part of lobe lies close to antero-lateral cephalic extremity, and posterior part virtually overhangs distal edge of occipital ring. Anterior branch of facial suture descends subparallel with axial furrow across anterior end of eye lobe, then turns sharply inwards and forwards to meet at mid-line; posterior branch of suture, after curving gently backward and inward between visual surface and palpebral rim, turns sharply downwards and outwards to pass along anterior margin of posterior area of fixed cheek, and then deflected sharply backwards to cut posterior margin between rounded projection on free cheek and fulcral socket on posterior area of fixed cheek. Rounded projection continuous into narrow, curved ridge of posterior border on free cheek; posterior border furrow similarly curved and intersecting posterior margin between rounded projection and short, slender genal spine (Pl. 52, figs. 9, 11); genal spine projects backward and slightly outward from about opposite occipital ring. Cheek outside eye lobe narrow, outward sloping, and subtriangular in

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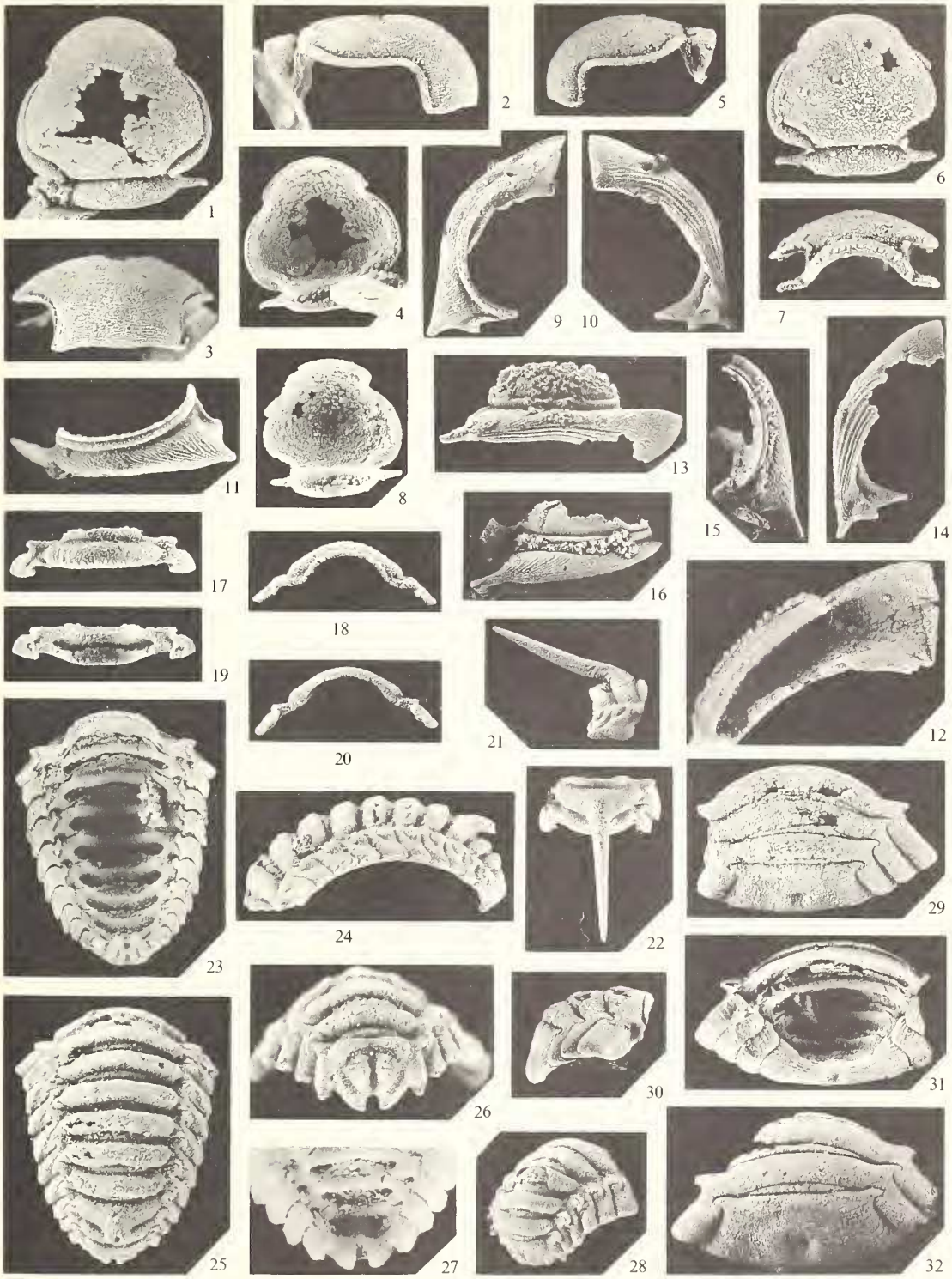
EXPLANATION OF PLATE 52

Figs. 1–28. *Remopleurides saenuros* sp. nov., from Ordovician limestone at Billabong Creek. 1–4, Dorsal, lateral, anterior, and ventral views of cranidium; holotype SUP 27932; 1–3, ×5; 4, ×4. 5–8, Lateral, dorsal, posterior, and ventral views of cranidium; paratype SUP 27933; 5–7, ×5; 8, ×4. 9–12, Dorsal, ventral, dorso-lateral, and oblique interior (enlarged) views of left free cheek; paratype SUP 27940; 9–11, ×5; 12, ×8. 13–14, Lateral and ventral views of right free cheek; paratype SUP 27935, ×5. 15–16, Dorsal and lateral views of right free cheek; paratype SUP 28900, ×5. 17–20, Dorsal, anterior, ventral, and posterior views of thoracic segment; paratype SUP 27949, ×5. 21–22, Lateral and dorsal views of two thoracic segments; paratype SUP 27941, ×5. Note median axial spine. 23–25, Ventral, lateral, and dorsal views of ten thoracic segments and pygidium; paratype SUP 27936, ×5. 26–27, Magnified views of dorsal and ventral surfaces of pygidium in articulated specimen of figs. 23–25; paratype SUP 27936, ×8. 28, Oblique view of five thoracic segments and pygidium; paratype SUP 27948, ×5. Median axial spine damaged.

Figs. 29–32. *Remopleurides* sp. A from Ordovician limestone at Billabong Creek, ×4. 29–31, Dorsal, lateral, and ventral views of pygidium and last three thoracic segments; SUP 27946. 32, Dorsal view of pygidium and two thoracic segments of SUP 27945.



WEBBY, *Remopleurides*

outline, with terrace lines running obliquely out to margins, separated from visual surface by convex external rim. Visual surface not well enough preserved to show facets.

Doublure of free cheek widest anteriorly towards mid-line; cut by median suture. Beneath eye lobe innermost part of doublure exhibits tendency to curl upward. Doublure narrows to just behind widest part of glabella, then widens posteriorly on to genal spine and into short, rounded projection of posterior margin. Crescent-shaped, convex forward, facet in doublure lies in front of, and between base of genal spine and rounded projection, allowing forward movement of first thoracic pleura during enrolment (Pl. 52, figs. 10, 14). Large pit on external surface of doublure in vertical line with anterior pit on antero-lateral corner of glabellar tongue; no cone-like structure seen to be developed. On inner part of doublure adjacent to median suture there is sharp downward deflection of inner edge of doublure forming one side of funnel-shaped opening on median suture (Pl. 52, figs. 9–10, 12). A similar feature is shown in *R. caphyroides* and *R. ligulus* (see Whittington 1959, pl. 7, figs. 4–7; 1963, pl. 4, fig. 3). Terrace lines prominent around doublure, running subparallel to lateral margins; also run out along genal spine.

Broad, convex axis of thorax tapers back to about one-half its width in length of ten thoracic segments; short, paddle-shaped pleurae inclined backward and outward beyond prominent fulcrum. Axial rings raised, with gentle slope forward (sag.), steepening on to anterior margin, and even steeper slopes around lateral and posterior margins. Relatively deep articulating furrow and moderately long (sag.) articulating half-ring. Median axial spine placed on third segment in front of pygidium; almost straight, tapering nearly to point in backward and upward direction, inclined at about 30° to crestal profile of adjacent axial rings. Spine 4·0 mm long, supported by axial ring 2·6 mm wide (Pl. 52, figs. 21–22). Articulating structures along short, transverse and horizontal anterior and posterior margins of inner part of pleurae. Anterior flange extends along anterior margin between enlarged rounded fulcral process antero-laterally, and small axial socket lying on axial furrow; on posterior side, posterior flange seems to be raised slightly between enlarged fulcral socket and small rounded axial process, protruding as ridge on to dorsal surface of inner part of pleura (Pl. 52, fig. 20). Vague suggestion of ring processes and sockets inside axial furrow, but not clearly differentiated. Outer parts of pleurae backwardly turned, with outer ends rather bluntly rounded, and more sharply pointed, posteriorly directed tips. Weak, diagonal pleural furrow runs across inner part of pleura, becoming ill defined near posterior margin on outer part of pleura.

Inner edge of doublure with gentle sigmoidal course from fulcral process backward to point just outside fulcral socket, giving over-all zigzag appearance to doublure along inner margin of thorax (Pl. 52, fig. 23). Posterior part of doublure on outer part of pleura flattened to form articulating facet for under-riding during enrolment of succeeding pleura; sharp curved (convex forward) break-in-slope between facet and gently convex anterior part of doublure. Tongue-like extension of doublure beneath axial ring, reaching forward about two-thirds total sagittal length. Ornamentation of thorax virtually restricted to faint lines in Bertillon pattern on dorsal surface of axis and pleurae; also a few granules scattered on pleurae, and along posterior margin of axial rings. Terrace lines run subparallel to lateral margins on doublure.

Pygidium subrectangular, wider than long, with lateral margins diverging slightly backwards; axis relatively long, subtriangular, tapering backward seemingly almost to deep U-shaped median notch on posterior border (Pl. 52, fig. 26). Articulating furrow sharply impressed, becoming deeper distally; articulating half-ring relatively long (sag.). First axial ring expands distally, and second axial ring divided by deep median longitudinal furrow. Owing to fusion of furrows it is rather difficult to interpret the precise nature of segmentation in posterior part of axis and relationships with pleural regions. Suggestion of pair of moderately large, oval muscle attachment areas lying over ring furrow between first and second axial rings, just inside weakly developed axial furrow. Two pairs of pleural ribs, with short, weak interpleural furrow between them; ribs extend into short, pointed pleural spines; the first pair shorter and diverging slightly outwards, the second pair tending to converge backwards. Prominent fulcral process on antero-lateral corner of pygidium. Doublure extends beneath pleural regions, and apparently beneath posterior part of axis just in front of deep median notch (Pl. 52, fig. 27). Extension of pygidial doublure in front of deep median notch perhaps implies axis is rather shorter than appears to be the case on the dorsal surface. Terrace lines continue subparallel to margin on pygidial doublure. In two specimens (Pl. 52, figs. 26, 28) pygidium has sagittal length of 1·6 and 1·5 mm, and maximum width of 2·1 and 2·2 mm, respectively.

Remarks. R. saenuros has a median axial spine placed on the third segment in front of the pygidium, whereas in most North American and European species of *Remopleurides* it occurs on the fourth segment in front of the pygidium, i.e. on the eighth thoracic segment where eleven thoracic segments are typical for the genus (Whittington 1950*a*, 1959; Shaw 1968; Ingham 1970). But in the most complete specimen of *R. saenuros* only ten thoracic segments occur (Pl. 52, figs. 23–27), and though it remains doubtful, there is nevertheless the possibility that this represents the full complement of thoracic segments for the species.

Even more distinctive is the pygidium of *R. saenuros*. Instead of the characteristic short and rapidly tapering two-segmented axis, and much broader and longer, flattened pleural regions, the axis of *R. saenuros* is relatively larger, triangular, and appears to extend back almost to the median notch, being virtually bisected by a deep and most prominent median longitudinal furrow, while the pleural regions are relatively narrow, having two pairs of short, pointed pleural spines, the outer pair divergent and the inner pair converging backward to either side of the median notch. Other small New South Wales species (*R. exallos* and *R. acer*) have a similar type of pygidium. None of the European and North American species seems to have a closely comparable pygidial construction. The pleural regions of the pygidium of *R. validus* Thorslund (1940) from the Lower Chasmops Limestone of Jemtland, Sweden, are similar, but this is the only resemblance. The pygidium as a whole is much broader, and the posterior part of the axis much shorter, with median longitudinal furrow shallower and considerably less extended.

Remopleurides exallos sp. nov.

Plate 51, figs. 3–12

Material. Holotype (SUP 28913) and seven paratypes (SUP 19937, 20902, 26942b, 28910, 28911a, 28912, 28914) from Copper Mine Creek, one paratype (SUP 19917) from Trilobite Hill, and three paratypes (SUP 27905b, 28905, 28906) from near Mirrabooka homestead, north of Cheeseman's Creek P.O. All specimens come from shales in the Malongulli Formation.

Comparative description. This species differs from *R. saenuros* chiefly in being somewhat larger, having a relatively longer (sag.) glabella and larger, more conspicuous spines. It has a much more marked, fine Bertillon pattern of terrace lines on the dorsal surface of the exoskeleton, excepting the furrows, and abundant granules on the median glabellar area adjacent to the occipital furrow and next to the posterior part of the palpebral furrows. Three pairs of lateral glabellar furrows are visible in some external and internal moulds (Pl. 51, figs. 3–4), equally spaced exsagittally, with the first curving and tapering outwards, the second, long, slender, and gently curved, and the third, short and transversely elongate.

Anastomosing terrace lines developed on the free cheeks and extend outward in a transverse direction from the region of the eye lobe, becoming deflected backwards near the lateral border. The posterior border has terrace lines arranged transversely along it. Granulation is also developed in the angle between the posterior part of the external rim of the eye lobe and the inner end of the posterior border furrow (Pl. 51, fig. 9). The external rim of the eye lobe has parallel lines along it, and scattered granules on its posterior part (Pl. 51, fig. 8). Visual surface is covered with many tiny, low facets arranged in diagonal rows. Well-developed genal spine with its base opposite occipital ring, and having prominent terrace lines running along its length. The posterior margin between the genal spine and the rounded posterior projection is straight and transverse, rather than curved as in *R. saenuros*.

Fine granulation is also developed on the posterior edge of axial rings of the thorax, particularly the anterior ones, and they occur to either side of the conspicuous diagonal furrow on the inner part of the thoracic pleurae (Pl. 51, fig. 11). Terrace lines run diagonally outward, parallel with the diagonal furrow on the outer part of the pleurae, towards the pointed spine-like pleural tips (more pointed than in *R. saenuros* but less drawn out than in *R. acer*). Terrace lines have forwardly convex course on axial rings, except for third axial ring in front of pygidium, where they are deflected backwards along straight, tapering median axial spine (Pl. 51, figs. 10, 12).

External moulds of pygidium show differentiation of raised, subtriangular axial region divided by long, deep, median longitudinal furrow almost intersecting first axial segment and continuous to just in front of median notch, and relatively narrow pleural region with two pairs of moderately elongated pleural spines (Pl. 51, fig. 12). First axial segment very narrow medially, widening rapidly distally. The ring furrow curves in arc outwards and backwards. Terrace lines represented on outer parts of segment, aligned diagonally in harmony with those on lateral parts of thoracic axial rings (Pl. 51, figs. 6, 12). Behind ring furrow are extensive raised triangular areas of the second axial segment to either side of longitudinal median furrow. Small

granules cover surface especially adjacent to the longitudinal median furrow. Laterally, close to angle between ring furrow and axial furrow, there is a smooth oval ?muscle area. Terrace lines run along length of pleural spines. A few granules also appear on the inner pleural area adjacent to the anterior margin. A narrow, arched, slightly elevated pleural area lies between posterior median notch and posterior tip of longitudinal median furrow, and exhibits terrace lines subparallel to the curve of the notch.

Remopleurides acer sp. nov.

Plate 53, figs. 1–10

Material. Holotype (SUP 28922) and fourteen paratypes (SUP 28915–28921, 28923–28926, 28928–28930) from the lower part of the Cliefden Caves Limestone, Fossil Hill.

Comparative description. R. acer closely resembles *R. saenuros* but may be distinguished mainly by having a more prominent, coarser Bertillon pattern of lines on the glabella, typically interrupted and deflected by the three pairs of lateral glabellar furrows (Pl. 53, figs. 1–3), by exhibiting more elongated, spine-like thoracic pleurae, even anteriorly (Pl. 53, fig. 8), and by having a pygidium with longer pleural spines and more conspicuous muscle scars on the axial region (Pl. 53, figs. 9–10). Again it is difficult to interpret precise nature of the segmentation in the pygidial axis because of fusion of the axial segments and imprint of deep, median longitudinal furrow. The first axial ring narrows medially, and ring furrow has a concave backward outline. The second axial ring is rather ill defined but bisected by deep, median longitudinal furrow, and appears to have large pair of oval- to crescent-shaped muscle scars antero-laterally, abutting ring furrow. Possibly another, slightly smaller, pair of scars is situated directly behind the first pair (Pl. 53, fig. 10). Terrace lines and granulation tend to be more prominent on the dorsal exoskeleton of *R. acer* than in equivalent parts of *R. saenuros.*

R. acer differs from *R. exallos* in being somewhat smaller, having a relatively less elongate (sag.) glabella, ornamented by a coarser Bertillon pattern of lines, and more elongated pleural spines on the thorax and pygidium. There is a less anastomosing, more obliquely, backwardly directed pattern of lines on the free cheek between the external rim of the eye lobe and the lateral border, and granulation is apparently lacking. The visual surface of the eye lobe also exhibits tiny eye facets in diagonal rows.

Remopleurides sp. A

Plate 52, figs. 29–32

Material. Three fragmentary silicified specimens (SUP 27945–27947) from Ordovician limestone at Billabong Creek.

Description. Only three thoracic segments in front of pygidium seen; no evidence of median axial spine on third thoracic segment in front of pygidium (Pl. 52, fig. 29). Very broad, smooth, gently convex axis, with deep, narrow articulating furrow and long (sag.) articulating half-ring. Pleurae divided by pronounced constriction at

fulcrum into narrow (tr.), transverse, gently convex inner part, strictly in continuity with axis because axial furrow not clearly imprinted on dorsal surface, and an outer part showing backward and outwardly inclined blunt, short, paddle-shaped form. Enlarged fulcral processes and sockets developed on pleurae, but no apparent diagonal furrow. Judging from rapid increase in width of thorax in successive segments forwards from pygidium, maximum width of thorax (and cephalon) is likely to be more than twice width of pygidium, perhaps considerably more. Doublure very wide, extending inwards to fulcrum; also extends forward beneath axial ring (Pl. 52, fig. 31).

Pygidium large, subtrapezoidal in outline, approximately two to two and one-half times wider than long. Deep transverse articulating furrow and long articulating half-ring at anterior margin. At antero-lateral extremities prominent fulcral processes, and laterally, facets to receive last pair of pleurae in enrolment. Axial and pleural areas not differentiated, but very broad, gently undulose surface of pygidium, weakly convex and sloping gently backwards; moderately large, rounded, median depression in posterior half of pygidium, and very shallow, smooth, elongate, transverse to gently curved furrow in front of median depression (Pl. 52, figs. 29, 32); appearing to represent pair of muscle attachment areas connected by narrower, gently forwardly curved band across mid-line; gentle depression extends in curve from outer ends of this structure to posterior margin between mid-line and postero-lateral extremities; dorsal surface exhibits raised lines running subparallel to gently curved

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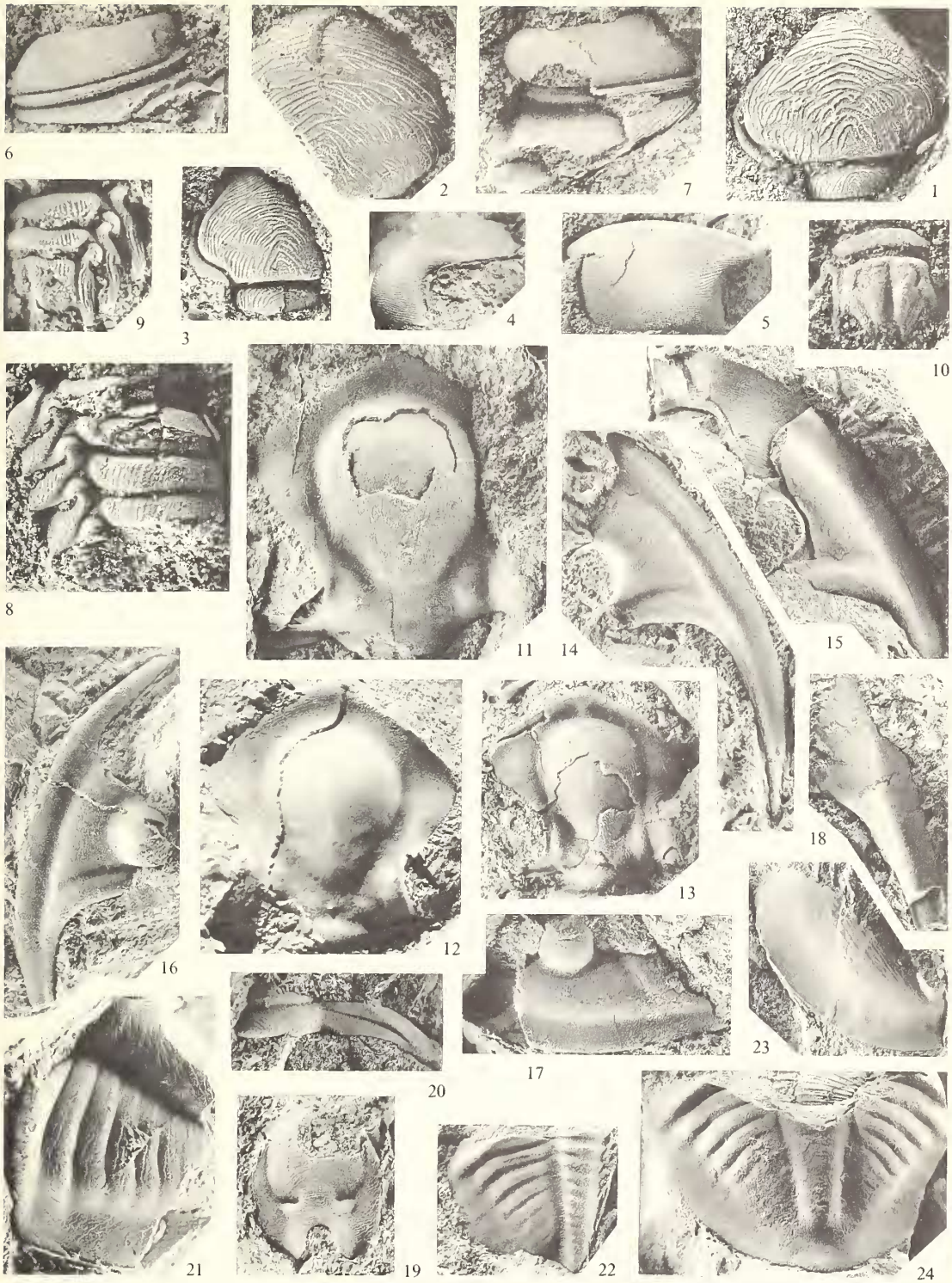
EXPLANATION OF PLATE 53

Figs. 1–10. *Remopleurides acer* sp. nov., from the lower part of the Cliefden Caves Limestone, Fossil Hill. 1, Dorsal view of latex impression of external mould of cranidium; holotype SUP 28922, ×6. 2, Dorsal view of latex impression of external mould of cranidium; paratype SUP 28924, ×8. 3, Dorsal view of latex cast of external mould of cranidium; paratype SUP 28915, ×6. 4–5, Lateral and anterior views of cranidium; paratype SUP 28923, ×5. 6, Lateral view of part of left free cheek; paratype SUP 28921, ×10. 7, Lateral view of portion of right free cheek; paratype SUP 28930, ×10. 8, Dorsal view of four thoracic segments; paratype SUP 28925, ×8. 9, Oblique dorsal view of part of pygidium and last two thoracic segments; paratype SUP 28920, ×10. 10, Dorsal view of pygidium and last thoracic segment; paratype SUP 28919, ×12.

Figs. 11–24. *Pseudobasilicus? fortis* sp. nov., from the lower part of the Cliefden Caves Limestone; 11–12, 14–17, 22–24 from 'mixed fauna' unit east of Fossil Hill; 13, 18–21 from 'lower coral' unit, Fossil Hill. 11, Dorsal view of latex impression of exfoliated cranidium; holotype SUP 37900, ×3. Note right, posteriorly placed palpebral lobe. 12, Dorsal view of cranidium showing internal mould of lateral glabellar furrows, median tubercle, and median ridge; paratype SUP 29939, ×4. 13, Dorsal view of small cranidium; paratype SUP 18947, ×5. Also note prominent posteriorly situated palpebral lobe. 14, Dorsal view of right free cheek and genal spine; paratype SUP 29941, ×2·5. Note prominent lateral and posterior borders. 15, Dorsal view of right free cheek showing doublure anteriorly; paratype SUP 17941, ×2. 16, Dorsal view of left free cheek; paratype SUP 29940, ×2·5. 17, Oblique lateral view of part of left free cheek showing elevated, rounded eye; paratype SUP 18901, ×2·5. 18, Ventral view of part of doublure beneath left free cheek and base of genal spine; paratype SUP 18908, ×2. 19, Ventral view of relatively small hypostome; paratype SUP 29948, ×6. 20, Dorsal view of part of thoracic segment; paratype SUP 17937, ×3. 21, Oblique lateral view of incomplete pygidium; paratype SUP 17943, ×4. Note conspicuous anastomosing lines. 22, Dorsal view of internal mould of part of pygidium; paratype SUP 37902, ×3. 23, Dorsal view of doublure on left side of pygidium; paratype SUP 29947, ×1·5. 24, Dorsal view of large pygidium showing prominent postero-lateral border; paratype SUP 17945, ×1·5.



WEBBY, *Remopleurides*, *Pseudobasilicus*?

posterior margin, except for part of median depression and elongate furrow. Another, smaller, rounded median depression occurs at posterior margin or just beneath on posterior edge of doublure (Pl. 52, fig. 31). Doublure broad, widest antero-laterally, presumably mainly underlying undifferentiated pleural regions; narrowing slightly backwards and inwards, but medially having slight forward and upwardly directed, tongue-like extension (Pl. 52, fig. 31). Terrace lines developed along pygidial and thoracic doublure, subparallel to margin. In two specimens (Pl. 52, figs. 29, 32) pygidium has sagittal length of 2·6 and 3·5 mm, and maximum width of 5·8 and 8·0 mm, respectively.

Remarks. The association of the small *R. saenuros* and the large *R.* sp. A in the same silicified limestone fauna at Billabong Creek suggests the possibility of dimorphism (see earlier discussion, p. 446). However, until a more complete specimen is obtained, it may still be argued that this large form represents an entirely new remopleuridid.

Remopleurides sp. B

Plate 51, fig. 13

Material. A single, large internal mould (SUP 28904) from the Malongulli Formation near Mirrabooka homestead, north of Cheeseman's Creek P.O.

Comparative description. The specimen shows six thoracic segments in contact with a damaged pygidium. The thoracic segments exhibit a very wide axis with gentle forward convexity, and shorter backward and outwardly curved pleurae. Terrace lines on the thoracic doublure are more or less subparallel to the margin. On the pygidium, there is an imprint of a large rounded median elevation (depression in doublure) between anterior and posterior margins, and transversely aligned terrace lines. The specimen reaches a maximum width of 34 mm measured across the fifth thoracic segment in front of the pygidium. It closely resembles *R.* sp. A, but because of its association in the Malongulli Formation with *R. exallos*, is thought to represent a dimorph of this species, rather than of *R. saenuros*.

Possibly the Australian forms belong to a distinct species group characterized by (1) smaller 'male' dimorphs with a median spine on the third thoracic segment in front of the pygidium, and a small pygidium with relatively large, triangular axis bisected by deep, median longitudinal furrow, and narrow, marginal pleural regions, and (2) large 'female' dimorphs, lacking a median thoracic spine and with a large, wide, poorly differentiated, subtrapezoidal pygidium.

Remopleurides sp. C

Plate 51, figs. 14–15

Material. Part of a damaged cranidium (SUP 28907), free cheek (SUP 28908), and posterior part of thorax and pygidium (SUP 28909) from Ordovician shales (not *in situ*), ½ mile north of Cheeseman's Creek P.O.

Comparative description. The character of the ornamentation on the free cheek of this species distinguishes it from other smaller New South Wales forms. Though perhaps most closely resembling *R. exallos*, the triangular area inside the lateral

border, limited by the posterior border furrow and the eye lobe, exhibits a prominent granulation (Pl. 51, fig. 15), and terrace lines are confined mainly to the genal spine, the lateral border, and the doublure. The posterior border is well developed, raised, smooth, and transversely aligned, unlike the narrow, curved ridge of the posterior border in *R. saenuros*.

Family ASAPHIDAE Burmeister 1843
Genus PSEUDOBASILICUS Reed 1931

Type species. Ptychopyge lawrowi F. Schmidt 1898.

Pseudobasilicus? fortis sp. nov.

Plate 53, figs. 11–24; Plate 54, figs. 1–4

Material. Holotype (SUP 37900) and eighteen paratypes (SUP 17940–17941, 17945–17946, 18901, 29936–29944, 29946–29947, 37902–37903) from the 'mixed fauna' unit east of Fossil Hill, lower part of the Cliefden Caves Limestone. Eleven paratypes (SUP 17937, 17943, 18902, 18908, 18947, 19907, 29909b, 29948, 37901, 37904–37905) from the 'lower coral' unit on Fossil Hill, lower part of the Cliefden Caves Limestone.

Description. Cephalon subsemicircular, wider than long (sag.), with prominent borders and strong genal spines. Glabella moderately convex, occupies between one-quarter and one-third total width of cephalon; defined by fairly well-differentiated axial furrows, continuous into preglabellar furrow anteriorly. Axial furrows not well defined posteriorly, except in small specimens and on internal moulds of larger ones, and extending more or less directly backwards on to posterior margin. One pair of prominent lateral glabellar furrows (*1p*) seen to run obliquely backwards and inwards from intersection with axial furrows near mid-length of glabella, and apparently meet at mid-line just in front of small, median glabellar tubercle, the latter situated on gentle rise of posterior part of glabella immediately in front of occipital furrow (Pl. 53, fig. 12). Internal moulds may show faintly impressed short, curved, convex forward, lateral glabellar furrows (*2p*) with weakly raised, crescent-shaped ridge just in front of each furrow; distally, *2p* furrows meet *1p* furrows, just behind their point of intersection with axial furrows. *2p* furrows subdivide convex, raised, pear-shaped anterior part of glabella into large frontal lobe and small, lateral glabellar lobes (*2p*). No observable differentiation of this pear-shaped anterior part of glabella is seen in external moulds (Pl. 53, fig. 11). Arched, subtriangular to L-shaped lateral glabellar lobes (*1p*) slope antero-medially toward *1p* furrow from raised course of axial furrow adjoining elevated palpebral lobe, and postero-laterally toward lateral development of occipital furrow. Occipital furrow becomes weakly defined and appears to be deflected slightly forwards medially. Internal moulds of glabella may show faint median ridge running forward from median tubercle across *2p* and frontal lobes (Pl. 53, fig. 12). Occipital ring gently convex, narrowing laterally owing to forward deflection of occipital furrow and slight backward curve of posterior margin medially. Frontal part of fixed cheeks expanded into flat wing-like areas, continuous into preglabellar areas. Anterior branches of facial suture dorsal-intra-marginal, but meet at margin frontally; branches of suture cut obliquely across

weak, transverse-curving antero-median ridge (representing part of antero-lateral cephalic border) on preglabellar area; median suture not developed on dorsal surface. In small specimen (Pl. 53, fig. 13) more deeply impressed preglabellar furrow separating frontal lobe from narrow, raised ridge on preglabellar area, and crossed by low, median, connecting ridge at mid-line. Palpebral lobe most elevated part of cranidium, set posteriorly and adjacent to lateral glabellar lobe *1p* (Pl. 53, figs. 11 and 13). Maximum width across posterior margin of cranidium similar to total width across frontal lobe of glabella and wings of fixed cheek.

Ornamentation consists of fine anastomosing lines running concentrically around frontal part of glabella, constricted posteriorly toward median tubercle (Pl. 54, fig. 1). Anastomosing lines on occipital ring also exhibit concentric, convex forward pattern. Lines directed outwards and forwards across axial furrow on to wing of fixed cheek just in front of palpebral lobe, and run more or less parallel to antero-lateral margin of cephalon on to preglabellar area. Across palpebral lobes, lines orientated longitudinally (exsag.).

Free cheek exhibits large elevated, rounded eye, situated posteriorly, only about

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EXPLANATION OF PLATE 54

Figs. 1–4. *Pseudobasilicus*? *fortis* sp. nov., from the lower part of the Cliefden Caves Limestone; 1, 3, from the 'mixed fauna' unit east of Fossil Hill, and 2, 4, from the 'lower coral' unit, Fossil Hill. 1, Enlarged dorsal view of external mould of part of cranidium showing pattern of concentric anastomosing lines; paratype SUP 29938, ×6. 2, Oblique lateral view of exfoliated pygidium, showing part of doublure; paratype SUP 37901, ×2. 3, Dorsal view of incomplete pygidium; paratype SUP 29946, ×3. 4, Ventral view of incomplete hypostome; paratype SUP 29909b, ×4.

Figs. 5–18. *Illaenus* (*Parillaenus*)? *incertus* sp. nov., from the 'calcarenite' unit at the top of the Ballingoole Formation, Malachi's Hill. 5, Dorsal view of internal mould of cranidium, showing posteriorly situated palpebral lobe, lateral muscle impressions, and median tubercle; holotype SUP 29932a, ×6. 6–7, Dorsal and oblique lateral views of exfoliated cranidium; paratype SUP 18934, ×4·5. 8, Dorsal view of small cranidium, showing one pair of glabellar muscle scars on internal mould; paratype SUP 18931, ×8. 9, Anterior view of latex impression of cranidium, showing pattern of anastomosing lines; paratype SUP 19941, ×5. 10, Ventral view of doublure on pygidium, showing smooth, even curve of inner edge; paratype SUP 29928, ×4. 11, Dorsal view of internal mould of pygidium; paratype SUP 29931c, ×3·5. 12, Antero-dorsal and oblique lateral views of paratypes SUP 18933c (upper) and SUP 18933b (lower), ×5. Note smooth curve of inner edge of doublure and of terrace lines on exfoliated part of lower specimen, and fine pitting and radiating lines on dorsal surface of upper specimen. 13, Dorsal view of internal mould of pygidium; paratype SUP 29932b, ×4. 14, Oblique lateral view of internal mould of cranidium; paratype SUP 18933a, ×4. 15, Dorsal view of partly exfoliated pygidium showing lateral muscle impression on one side and six pairs of small axial muscle scars on internal mould; paratype SUP 29928b, ×5. 16, Dorsal view of exfoliated pygidium; paratype SUP 29931a, ×4. 17, Dorsal view of internal mould of small cranidium showing diverging axial furrows; paratype SUP 17700, ×6. 18, Ventral view of small pygidium showing trace of axial furrows anteriorly, one pair of lateral muscle impressions, fine, weak median ridge (groove ventrally) posteriorly, and smooth curve of inner edge of doublure; paratype SUP 29929, ×8.

Figs. 19–20. *Illaenus* (*Parillaenus*)? *incertus* sp. nov.?, also from 'calcarenite' unit at top of Ballingoole Formation, Malachi's Hill. 19, Dorso-lateral view of left free cheek, showing moderate-sized, crescent-shaped faceted eye; SUP 29928a, ×8. 20, Ventral view of internal mould of incomplete hypostome; SUP 18900, ×3.

Fig. 21. *Illaenus* (*Parillaenus*)? sp. A. Dorsal view of internal mould of compressed pygidium from the Malongulli Formation near Mirrabooka homestead, Cheeseman's Creek area; SUP 29935, ×4.


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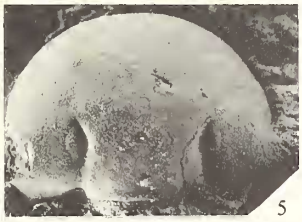
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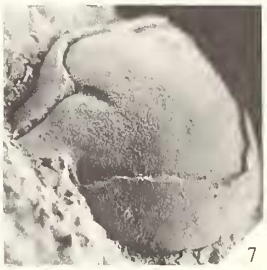
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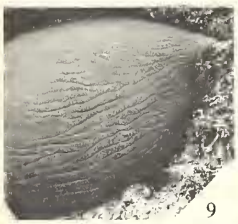
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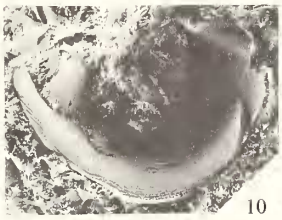
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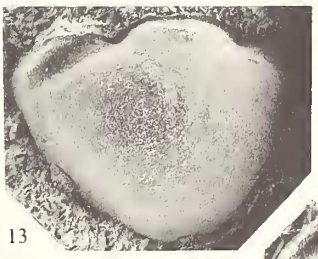
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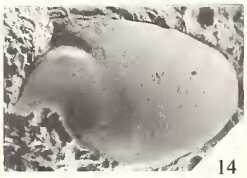
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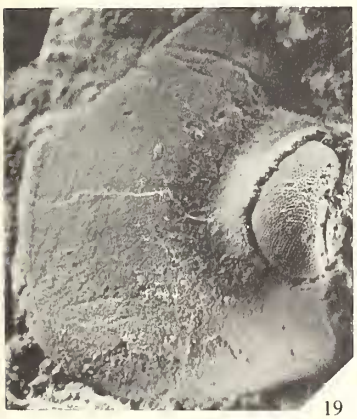
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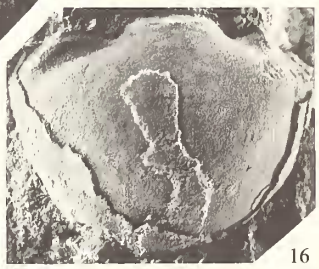
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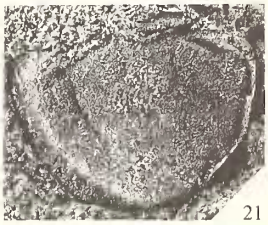
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WEBBY, *Pseudobasilicus*?, *Illaenus* (*Parillaenus*)?

one-half its exsagittal length in front of posterior margin. Almost upper three-quarters of eye surface composed of visual area, which extends in large arc of nearly 270°; visual area merges into eye-socle without break-in-slope, but there is change in colour of exoskeleton and subhorizontal terrace lines appear on socle. Eye-socle curves smoothly down into broad, gently convex platform of free cheek inside prominent lateral border. Change-in-slope at inner edge of lateral border represents lateral border furrow, which weakens posteriorly along genal spine. Anterior part of free cheek has long, narrow extension of border, which tapers and descends approaching mid-line (Pl. 53, fig. 16). Posterior border relatively broad, gently convex, transverse on inner part but curving gently backward into genal spine laterally, flanked by shallow, depressed posterior border furrow, which appears to die out approaching lateral border. Posterior border raised slightly above convex platform area of free cheek. Genal spine has subtriangular cross section, with dorsal keel on inner edge being continuous into raised posterior border, weakly concave outward slope as continuation of lateral border, and ventro-lateral keel as extension of lateral margin of cephalon. Inner and ventral surfaces of spine flattened and at right angles to each other (Pl. 53, fig. 18). Spine estimated to extend back to near three-quarters of total length of thorax; sharply pointed and evenly curved backward in continuity with lateral border.

Doublure underlies entire free cheek except near eye lobe and apparently beneath posterior border furrow; also extends under wing of fixed cheek in front of palpebral lobe and preglabellar area. Anteriorly, crossed by median suture, and indented by prominent, broad, deep anterior notch; small, tongue-like deflection in even forward and inward curve of anterior notch close to mid-line (Pl. 53, fig. 15). Nature of inner edge of doublure postero-laterally to eye lobe not known, and Panderian structures not clearly observed. Terrace lines run subparallel to margins of cephalon, along lateral and posterior borders, genal spine, and doublure; anastomosing lines on platform area inside border curve around eye lobe, and directed backward to posterior border furrow.

Hypostome of forked asaphid type, subovate, somewhat longer than wide, and with middle body gently convex; divided by deep, transverse, slot-like, middle furrows into large anterior, and very small posterior lobe. Macula conspicuous, transversely ovate, steeply inclined forward, situated on posterior side of middle furrow. Lateral and posterior borders broad and long (exsag.) with deep posterior median notch; sides only slightly divergent; posterior notch occupies about one-quarter of total length (sag.) of hypostome. Inner edges of posterior notch, raised; laterally descending on to flattened lateral borders; just in front of hypostome mid-length, lateral borders narrow into shoulder, which dies out anteriorly. Lateral notch lies between shoulder and curving antero-lateral margin of middle body; extends upward and outward into anterior wing. No anterior border. Doublure unknown. Anastomosing terrace lines have concentric, convex forward pattern across middle body, and more or less transverse arrangement of lines on posterior and lateral borders, with forward deflection at lateral margins.

One poorly preserved specimen shows five thoracic segments and pygidium articulated together. Axial rings convex (sag. and tr.), each separated by relatively shallow articulating furrow from convex, tongue-like articulating half-ring, about three-

quarters of length (sag.) of axial ring. Inner part of pleura flat, transverse; outer part deflected slightly backwards and downwards beyond fulcrum. Character of pleural ends and doublure unknown. Deep, sharp pleural furrow commences close to front edge of inner corner of pleura and follows slightly oblique course, becoming deepest near middle of pleura about fulcrum, and dying out near rear edge of pleura some distance inside pleural termination. Large triangular facet on anterior side of pleura beyond fulcrum, allowing articulation beneath posterior edge of preceding pleura; bounded posteriorly by sharp ridge running obliquely outwards and backwards from fulcrum toward postero-lateral corner of pleural termination. Anastomosing lines on axial ring concentrically arranged convex forward, and extend in continuity across articulating furrow on to articulating half-ring. On inner part of pleura, lines directed forward and very slightly outward; articulating facet apparently smooth.

Pygidium subsemicircular, moderately convex; axis occupies about one-quarter of total width at anterior margin; articulating half-ring and articulating furrow as in thoracic segments. Axis raised, gently tapering posteriorly to rounded termination set inside broad, flattened posterior border. As seen in internal moulds, number of axial rings difficult to determine but at least twelve (seven to nine in anterior two-thirds of axis). Ring furrows more deeply impressed laterally than medially. In external moulds axial rings faintly or not at all defined. Pleural region exhibits raised first pleural rib, continuous to lateral margin, with large triangular facet on its antero-lateral surface. Broad, flattened border terminates against first pleural rib. Inside border up to seven additional pleural ribs may be differentiated in internal moulds, but only anterior four or five are clearly seen on external surfaces, separated by sharply indented pleural furrows. Faint, discontinuous interpleural furrows may be developed on a few anterior pleural ribs (Pl. 53, fig. 22). Doublure broad, extending beneath border areas and outer part of pleural field. Inner edge runs in gentle curve from fulcrum towards posterior part of axis and is deflected in smooth sharp curve around termination, giving rounded notched appearance. Broad spaced, anastomosing terrace lines on dorsal surface run in rather sharp forward curve across axis, extend outward along pleural ribs, and outward and forward across border, usually with backward deflection at margin; they also cross triangular facet. Well-developed terrace lines run along doublure subparallel to posterior and lateral margins.

Judging from some large fragments of free cheeks, it is estimated that this species may have reached a maximum length of about 105 mm, and a maximum width across cephalon of about 60 mm.

Remarks. P.? fortis bears moderately close resemblances to the type species of *Pseudobasilicus*, *P. lawrowi* (Schmidt 1898), from the Middle Ordovician (C_1) of the Leningrad region and Estonia, but differs in exhibiting a slightly more inflated, pear-shaped glabella, a slightly narrower preglabellar area, more prominent lateral cephalic borders, larger genal spines, and less pointed, backwardly curving thoracic pleurae. Also the proportions across the posterior part of the cephalon are rather different, with the glabella occupying about one-quarter of the total cephalic width in *P. lawrowi*, and nearer one-third of the total width in *P.? fortis*. In consequence the present species is only tentatively assigned to the genus. Schmidt's (1898, 1904)

other two Middle Ordovician species of *Pseudobasilicus*, *P. kuckersianus* and *P. kegelensis*, from horizons C_{II} and D_{II}, respectively, of Estonia, with their much elongated, flattened preglabellar area, seem to be less closely related. Balashova (1971), in recent revision of Schmidt's species, has erected a new genus, *Pseudobasiliella*, for *P. kuckersianus* and *P. kegelensis*. *Pseudobasilicus*? *brachyrachis* (Törnquist) from the Middle Ordovician of the Siljan district, Sweden (Jaanusson 1953), is also similar to the present species, but it too has several distinguishing points —a more obtuse angle of intersection of anterior branches of the facial suture at the mid-line, lack of prominent lateral cephalic borders, shorter, more rapidly tapering genal spine, and wider pygidial doublure with more acute V-shaped inner edges.

Of South-East Asian forms, *Basiliella satunensis* Kobayashi and Hamada (1964) from Ordovician shales at Satun, southern Thailand, seems to be most closely related. Though fragmentary, the cranidia of the Thai species are very closely similar to those of *P.*? *fortis*. Kobayashi and Hamada described the species as having anterior branch of facial suture 'a little intramarginal', seemingly on dorsal side, 'then abruptly bent forward to meet its fellow on the axis', presumably marginally. From their statement and illustrations (pl. IX, fig. 1a–b), it is clear they correctly interpreted the suture as extending dorsal-intra-marginally along the border, swinging across the ridge-like edge of the border approaching the mid-line, and descending to meet the other branch on the margin, almost exactly analogous to that seen in *P.*? *fortis*. But they assigned the species to *Basiliella* Kobayashi, a sub-genus of *Basilicus* Salter, characterized by having a marginal suture in front of the glabella (Jaanusson 1959, p. O 336). The eyes of *B. satunensis* are stated as being placed about mid-glabellar length (Kobayashi and Hamada 1964, p. 208). Yet a poorly preserved imprint of the free cheek (pl. IX, fig. 6) actually shows the posterior edge of the eye lobe running into the posterior border furrow. The large eyes seem to be situated posteriorly with raised palpebral lobes as in *P.*? *fortis*. Therefore, the Thai species should perhaps like *P.*? *fortis* be tentatively assigned to *Pseudobasilicus*. The basic differences between the two species lie in the shorter and less slender genal spine, and hypostome with wide diverging inner margins of posterior notch of *P.*? *satunensis*.

The presence of a raised, median ridge across the preglabellar area of the small specimen of *P.*? *fortis* (Pl. 53, fig. 13) may invite the suggestion of a distant link with species like *Basiliella carinata* Harrington from the Upper Tremadocian of Argentina (Harrington and Leanza 1957, p. 144).

Pseudobasilicus? sp. A

Plate 55, figs. 1–19

Material. Fragmentary silicified cranidium, large and small free cheeks, an almost complete hypostome, and two fragmentary pygidia from Ordovician limestone at Billabong Creek (SUP 37906–37913); also incomplete hypostome from Quondong Formation, Bowan Park (SUP 37914).

Comparative description. This species is described with particular emphasis on characters which distinguish it from *P.*? *fortis*, and on additional features not seen in the latter. Small, weakly convex, fragmentary cranidium has less inflated frontal

lobe, narrower, posteriorly tapering wings of fixed cheek, and relatively larger, though less elevated, palpebral lobe (Pl. 55, fig. 1). Large specimen of free cheek (Pl. 55, figs. 2–4) retains part of visual surface of eye, showing on inside surface numerous tiny hexagonal facets; relatively longer (exsag.) and less elevated eye than in *P.? fortis*. Inner edge of doublure extends in gentle curve outward from just inside posterior margin (Pl. 55, fig. 3); detailed nature of course uncertain because of incomplete silicification, and no evidence of Panderian structures. In small specimens, lateral border narrows posteriorly toward relatively smaller genal spine (Pl. 55, figs. 5–7). Faint terrace lines on doublure, borders, and genal spine.

Hypostome with gently convex, subrounded middle body, subdivided into large anterior, and very small posterior lobes by marked, transversely elongate middle furrows. Small, ovate, forwardly tilted macula situated near lateral border just behind middle furrow. Broad, flattened, lateral, and posterior borders with bluntly pointed postero-lateral prongs to either side of notch, and diagnostic sharp nick half-way along margin of lateral border. Inner, ventral edges of notch sharply crested; sides slope upward and outward on to convex, dorsal surface of posterior part of doublure. Inner edge of doublure turns sharply upward into short, posterior wing directly above and behind macula; inclined inward and backward at about 45° to exsagittal line. Broad, shallow groove running forward along doublure outside posterior wing, continuous into downward and forwardly curving lateral notch between shoulder and anterior wing; possibly formerly occupied by antenna or similar structure. Inner edge of doublure between posterior wing and shoulder slightly upturned. Anterior margin curved gently forward, but with small, shallow notch across mid-line. Backward and upward continuation of anterior margin runs into very broad anterior wing. Anterior wing broad, subtriangular, upwardly and backwardly directed; dorsal edge slightly damaged, but well enough preserved to show, in side view, asymmetrical profile with gentle backward curve anteriorly and sharply deflected postero-dorsal tip. Anastomosing terrace lines directed more or less transversely across middle body and in front of posterior median notch; deflected forwards on either side across lateral borders, shoulders, and lateral notches to intersect anterior margin obliquely.

Pygidium gently convex, with much less well-differentiated axis and pleural regions than in *P.? fortis*. Only very faint trace of about seven pleural ribs on internal surface of large specimen, 39·5 mm long (sag.) and estimated to have been about 46 mm wide (Pl. 55, fig. 13); evenly curved margin but for slight flattening of posterior margin and very weak upward deflection medially (Pl. 55, fig. 16). Less prominent lateral and posterior borders than in *P.? fortis*. First pleural furrow very weakly developed. Axis occupies about three-sevenths of total width of pygidium anteriorly. Broad tongue-like appearance of articulating half-ring. Triangular articulating facet with moderately sharply rounded antero-lateral corner. Doublure occupies about one-half width of pleural field anteriorly; inner edge gently curved between fulcrum and posterior end of axis, broadly V-shaped, sharply rounded at posterior end of axis; terrace lines well exhibited subparallel to margin (Pl. 55, figs. 13 and 18). In large specimen, ornamentation of scallop-shaped markings especially on lateral border; irregular to transverse, widely spaced lines inside lateral border (Pl. 55, figs. 15–16). Smaller specimen exhibits anastomosing lines intersecting margin

obliquely, directed forward and outward, and fine pitting (Pl. 55, figs. 17 and 19); terrace lines also run outward on facet.

To sum up, *P.*? sp. A is distinguished from *P.*? *fortis* in the following main characters: (1) a less inflated frontal lobe, narrower wing-like lateral areas of fixed cheeks of cranidium, and relatively longer (exsag.) and less elevated eyes, (2) a prominent nick on lateral margin of border of hypostome, and (3) a poorly differentiated axis and pleural regions of pygidium.

Family ILLAENIDAE Hawle and Corda 1847
Genus ILLAENUS Dalman 1827
Subgenus PARILLAENUS Jaanusson 1954

Type species. Illaenus fallax Holm 1882.

Illaenus (*Parillaenus*)? *incertus* sp. nov.

Plate 54, figs. 5–18

Material. Holotype (SUP 29932a) and nineteen paratypes (SUP 17700, 18928, 18931–18932, 18933a–c, 18934, 19914, 19941, 20905, 20910, 29928b, 29929, 29931a–c, 29932b, 29933) from the 'calcarenite' unit of the Ballingoole Formation, Bowan Park Group (Semeniuk 1970), at Malachi's Hill.

Description. Cranidium moderately convex, subsemicircular in outline, wider than long; widest across posteriorly placed palpebral lobes; glabella in posterior part of cranidium bounded by prominent, fairly deep axial furrows as seen in internal moulds, but only weakly developed in external moulds. From posterior margin, axial furrows directed forward and slightly inward to inner edges of pair of large, exsagittally elongate, oval lateral muscle impressions (lunettes); appear to be deflected forward and outward in front of impressions; internal moulds of small specimen (Pl. 54, fig. 17) exhibits weakly impressed axial furrows diverging outwards in front of lateral muscle impressions. Lateral muscle impressions set only slightly in front of palpebral lobes, at about one-third of total cranidial length (sag.) from posterior margin. Just in front of anterior edges of lateral muscle impressions, and immediately across axial furrows on glabella, are pair of elongate, obliquely placed

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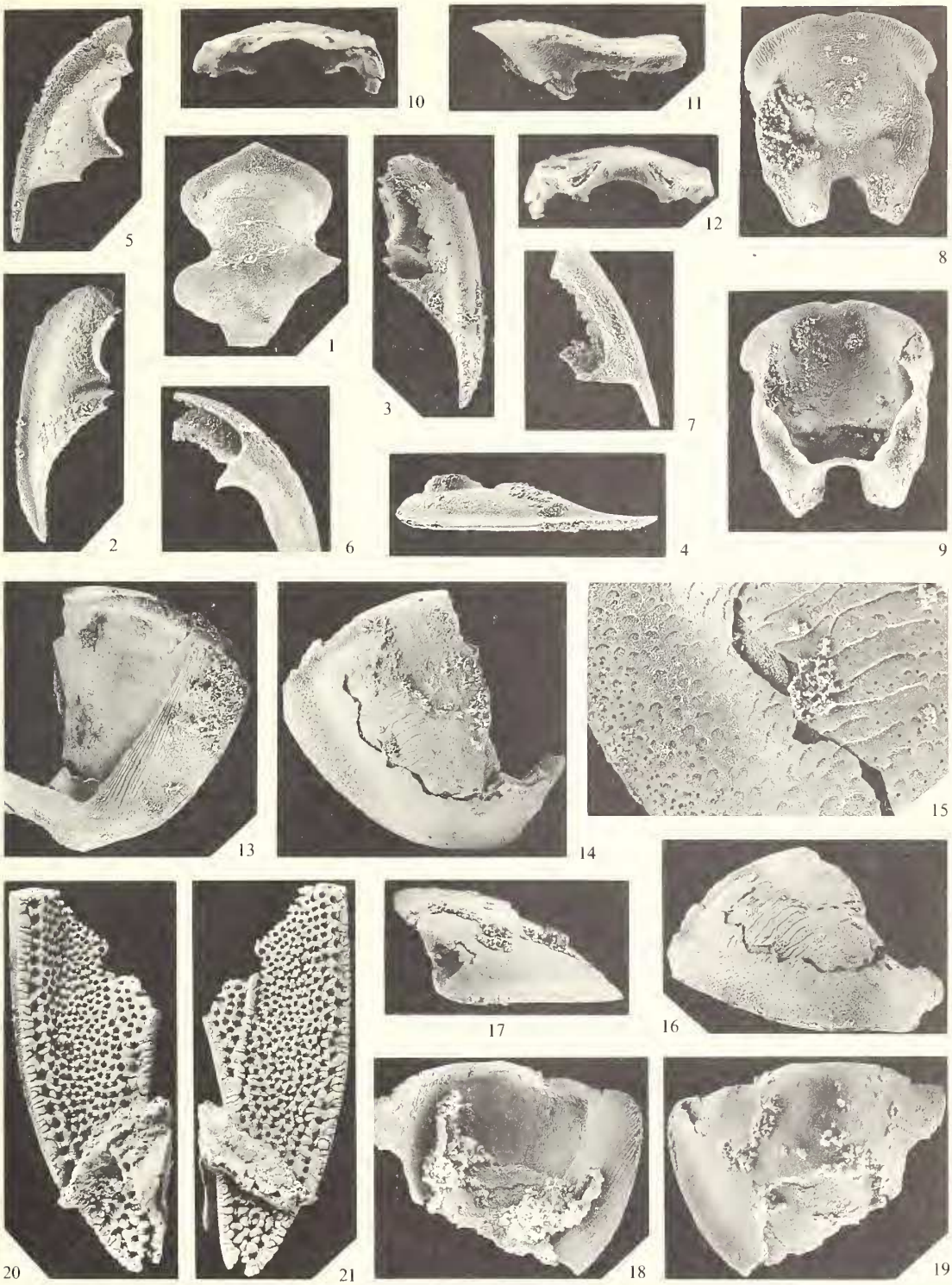
EXPLANATION OF PLATE 55

Figs. 1–19. *Pseudobasilicus*? sp. A from Ordovician limestone at Billabong Creek. 1, Dorsal view of part of cranidium; SUP 37906, ×3. 2–4, Dorsal, ventral, and lateral views of part of left free cheek; SUP 37907, ×1·5. 5, Dorsal view of left free cheek of small specimen; SUP 37908, ×4. 6, Dorsal view of anterior part of right free cheek of small specimen; SUP 37909, ×4. 7, Ventral view of posterior part of left free cheek of small specimen; SUP 37910, ×4. 8–12, Ventral, dorsal, anterior, lateral, and posterior views of nearly complete hypostome; SUP 37911, ×3. 13–16, Ventral, dorsal, enlarged dorsal, and posterior views of large fragmentary pygidium; SUP 37912; 13–14, 16, ×1; 15, ×3. Note scallop-shaped ornament on dorsal surface of lateral border. 17–19, Lateral, ventral, and dorsal views of incomplete pygidium; SUP 37913, ×2·5.

Figs. 20–21. Harpid gen. et sp. ind. Dorsal and ventral views of incomplete specimen of fringe from Ordovician limestone at Billabong Creek; SUP 29949, ×4.



WEBBY, *Pseudobasilicus*?, harpid

glabellar muscle scars (basal scars of Jaanusson 1954); they are orientated more or less at right angles to adjacent axial furrows and subparallel to antero-lateral margins of cephalon (Pl. 54, figs. 5 and 8). Glabellar width at level of palpebral lobes about three-sevenths of total cranidial width. Toward posterior margin, tiny median tubercle well exhibited on internal moulds of glabella. Internal mould of posterior margin of glabella shows narrow rolled edge, or incipient doublure. Posterior branch of facial suture runs only short distance backward on to posterior margin; anterior branch of suture has somewhat sigmoidal course, firstly forward and slightly outward, then curving gently inward to meet margin antero-laterally; sharp curve at margin into connective suture which continues in gentle arc flanked by doublure of free cheek and presumably rostral plate. Anteriorly, cranidium strongly curved downward, with greatest curvature towards ventral edge, giving slightly backwardly deflected anterior margin. In anterior aspect, outline made by deflected anterior margin seems to be flattened and horizontal. Anterior part of cranidium exhibits anastomosing terrace lines subparallel to margin, appearing like more or less horizontally arranged contours with slight backward and upward deflection along anterior branch of suture (Pl. 54, fig. 9).

From outline of facial suture and position and size of palpebral lobe, free cheek seems to have been rather small, with eye situated posteriorly. One large fragmentary specimen (Pl. 54, fig. 19) of a free cheek from the same locality and horizon, possibly belonging to the species, shows a moderately large, crescent-shaped eye with numerous tiny facets, and evenly rounded genal angle.

Only broken fragments of rostral plate seen; surface with very coarse transverse terrace lines.

Hypostome (Pl. 54, fig. 20), also from same locality and horizon, provisionally placed in species; relatively large, and exhibits almost straight, unnotched anterior margin, with expanded anterior wing. Anterior lobe of middle body subcircular, moderately convex, separated by deep furrow from lateral border. Lateral margins incompletely preserved. Middle furrow runs backward and inward from deep lateral border furrow, and dies out adjacent to small, oval macula. Posterior lobe of middle body poorly differentiated, especially medially; separated from raised, gently arched posterior border by broad (sag. and exsag.) and deep postero-lateral border furrow. Faint, small pits and subconcentrically, well-spaced lines developed on surface of middle body, and lines run parallel to margin on posterior border.

Thoracic segments unknown, but judging from relative widths of posterior margin of glabella and anterior edge of pygidial axis, narrows only slightly backward along thorax.

Pygidium moderately convex (tr. and sag.), subsemicircular in outline; widest across anterior part, just behind antero-lateral corner; slightly wider than long. Axis occupies about one-third of pygidial width anteriorly; usually only differentiated from pleural areas at anterior margin; axial furrows deeply impressed at margin with small downward and backward deflection of anterior edge. Relatively broad, shallow, diagonal furrow arises at anterior extremity of axial furrow and continues back and out toward lateral margin; isolates from rest of pygidium rather small, narrow, raised first pleural lobe with steep forward and outward facet-like area on antero-lateral corner. Doublure narrow, about one-fifth length (sag.) of

pygidium, evenly rounded laterally and posteriorly, with very slight narrowing in antero-lateral direction; not indented or notched sagittally; terrace lines, usually about 10–12, run subparallel to margin. On undersurface of one well-preserved small specimen (Pl. 54, fig. 18), trace of axial furrows seen extending backward from anterior margin toward large pair of oval, exsagittally elongate 'lateral' muscle impressions; rear edge of these impressions near mid-length of pygidium; axis forms subtriangular area lying inside axial furrows, with lateral muscle impressions apparently situated on outer side of axial furrows, strictly on inner part of pleural field. Axis tapers to point immediately behind rear edge of these muscle impressions, with faint, fine median ridge, seen as furrow on undersurface, continuing to inner edge of doublure. Pattern of muscle scars on axis preserved on internal mould of one well-preserved specimen (Pl. 54, fig. 15). Faint trace of large, crescent-shaped lateral muscle impression (one of a pair) and, on axis, inside and to front of it, six pairs of small muscle scars. First three pairs faint, elongate scars, closely spaced and almost transversely aligned; fourth pair, larger, pear-shaped and placed diagonally just in front of lateral muscle impression; last two pairs, subequal, rounded, set in line (but inside line of fourth pair), opposite anterior part of lateral muscle impression. Dorsal surface usually smooth, but one specimen (upper, Pl. 54, fig. 12) shows fine, widely spaced lines with intervening tiny pits running postero-laterally away from axis.

Remarks. This species may eventually prove to belong to a new genus, but additional, preferably articulated, material must be found and prepared to elucidate details of the rostral plate. It exhibits similarities to both *Illaenus* (*Parillaenus*) and *Bumastus* Murchison, though strictly is not identical with either. The relatively narrow posterior part of the glabella and the less outwardly diverging axial furrows to the front are features more typical of *Illaenus* (*Parillaenus*) than *Bumastus*. Neither genus, nor for that matter any other illaenid, appears to have the same pattern of an elongate, 'basal' glabellar muscle scar situated beside the axial furrow as in *I.* (*P.*)? *incertus*.

The even curve of the inner margin of the pygidial doublure, which characterizes the *Parillaenus* group (Jaanusson 1954), is displayed by the New South Wales species, though not with a shallow median furrow on the surface of the doublure as sometimes occurs in the type species, *I. fallax* Holm, from the Kullsberg and Chasmops Limestones of Sweden (Warburg 1925). Unfortunately, no pygidial muscle impressions have been recorded from species of *Illaenus* (*Parillaenus*) for comparison. In *Bumastus bouchardi* (Barrande) from the Silurian of Bohemia, Šnajdr (1957) has recorded two pairs of pygidial muscle impressions, a large postero-lateral, and a small, antero-median pair. The large, postero-lateral pair resembles the large, lateral pair of impressions in *I.* (*P.*)? *incertus*. But the one small antero-median pair bears little resemblance to the pattern of six small 'axial' pairs of scars of *I.* (*P.*)? *incertus*.

The present species also has similarities with forms like *Bumastus* (*Bumastoides*) *aplatus* (Raymond) from the Chazyan of New York (Shaw 1968). However, the relatively more widely spaced axial furrows on the cranidium behind the lateral muscle impression, and the relatively wider and more flattened pygidium, with the pygidial doublure exhibiting on its ventral surface a shallow median furrow, readily distinguish the Chazyan species.

Features of the cranidium of *I.* (*P.*)? *incertus*, particularly the moderately small, posteriorly situated eyes and the palpebral lobes placed well out from the axial furrows, suggest a close relationship with *Stenopareia* Holm 1886. But the hypostome and pygidium are markedly different. In the type species of *Stenopareia*, *S. linnarssoni* (Holm 1882) from the Boda Limestone (Middle Ashgill) of the Siljan district, Sweden, the hypostome is short (sag.) and subpentagonal, and the pygidium has strongly truncated antero-lateral angles and a pygidial doublure with a sharply pointed, forwardly directed projection on the mid-line (Holm 1886, Warburg 1925).

Illaenus (*Parillaenus*)? sp. A

Plate 54, fig. 21

Material. One specimen (SUP 29935) from shales of the Malongulli Formation near Mirrabooka homestead, north of Cheeseman's Creek.

Comparative description. This specimen is somewhat flattened by compression and poorly preserved, but does show a relatively narrower axis at anterior margin of pygidium, and apparently a somewhat broader doublure.

Family HARPIDAE Hawle and Corda 1847
Harpid gen. et sp. ind.

Plate 55, figs. 20–21

Material. Numerous silicified fragments of fringe from upper part of Cliefden Caves Limestone and Ordovician limestone at Billabong Creek. One diagnostic specimen (SUP 29949) from Billabong Creek shows prolongation of fringe and girder.

Description. On lower lamella of fringe, raised girder extends obliquely in to gently curving internal rim of prolongation behind postero-lateral corner of cheek. On upper lamella, narrow, slightly irregular band corresponds to girder beneath, lying between pitted areas of genal roll prolongation and brim prolongation respectively. Genal roll prolongation steeply sloping; brim prolongation concave, becoming flatter posteriorly, with gentle outward slope. Prominent gently curving, convex external rim with adjacent row of coarse pits; pronounced ridge on upper lamella and corresponding weaker 'pseudogirder' on lower lamella inside row of coarse pits; toward tip of prolongation, ridge dies out. External rim has trace of marginal suture dividing it into two; marginal band relatively broad, slightly concave above and below fine median ridge with trace of suture. Numerous, irregular pits covering surface of brim prolongation, with slightly larger pits adjacent to outer ridge, girder and preserved fragment of genal roll prolongation. Approximately eleven rows of pits between girder and external rim. Some fringe fragments show typical harpid feature of fine radiating, somewhat anastomosing ridges across row of pits.

Remarks. Judging from the number of silicified fragments, this harpid species is fairly abundant in the limestones. It probably represents a new Australian genus, bearing resemblances to *Selenoharpes* Whittington (1950*b*) in having a girder which intersects the internal rim, but differing fundamentally in showing a ridge and

corresponding 'pseudogirder' immediately inside the first row of large pits at the external margin, and narrower prolongations with relatively coarser and fewer rows of pits. A Lower Ordovician harpid has been recorded from Waratah Bay, Victoria (Singleton, in Lindner 1953), and, more recently, Whittington and Hughes (1972) have listed a harpid from the Gordon Limestone of Tasmania.

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